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SOME THOUGHTS ON MODERN MATHEMATICAL RESEARCH[1]

MATHEMATICS has a large household and there are always rumors of prospective additions despite her age and her supposed austerity. Without aiming to give a complete list of the names of the members of this household we may recall here a few of the most prominent ones. Among those which antedate the beginning of the christian era are surveying, spherical astronomy, general mechanics and mathematical optics. Among the most thriving younger members are celestial mechanics, thermodynamics, mathematical electricity and molecular physics.

Usually a large household serves as one of the strongest incentives to activity, and mathematics has always responded heartily to this incentive. As the most efficient continued service calls for unusual force and ingenuity, mathematics has had to provide for her own development and proper nourishment in addition to providing as liberally as possible for her household. This double object must be kept prominently before our eyes if we would comprehend the present mathematical activities and tendencies.

There is another important incentive to mathematical activity which should be mentioned in this connection. Mathematics has been very hospitable to a large number of other sciences and as a consequence some of these sciences have become such frequent visitors that it is often difficult to distinguish them from the regular members of the household. Among these visitors are

[1] Read before the Illinois Chapter of the Society of the Sigma Xi, April, 1912.

economics, dynamical geology, dynamical meteorology and the statistical parts of various biological sciences. Visitors usually expect the best that can be provided for them, and the efforts to please them frequently lead to a more careful study of available resources than those which are put forth in providing for the regular household.

We have thus far spoken only of what might be called the materialistic incentives for mathematical development. While these have always been very significant, it is doubtful whether they have been the most powerful. Symmetry, harmony and elegance of form have always appealed powerfully to dame mathematics; and a keen curiosity, fanned into an intense flame by little bits of apparently incoherent information, has inspired some of the most arduous and prolonged researches. Incentives of this kind have led to the *mathematics of the invisible*, relating to refinements which are essentially foreign to counting and measuring. The first important refinement of this type relates to the concept of the irrational, introduced by the ancient Greeks. As an instance of a comparatively recent development along this line we may mention the work based upon Dedekind's definition of an infinite aggregate as one in which a part is similar or equivalent to the whole.[2]

Mathematics is commonly divided into two parts called pure and applied, respectively. It should be observed that there are various degrees of purity and it is very difficult to say where mathematics becomes sufficiently impure to be called applied. The engineer or the physicist may reduce his problem to a differential equation, the student of differential equations may reduce his troubles to a question of function theory or geometry, and the workers in the latter fields find that many of their difficulties reduce themselves to questions in number theory[3] or in higher algebra. Just as the student of applied mathematics can not have too thorough a training in the pure mathematics upon which the applications are based so the student of some parts of the so-called pure mathematics can not get too thorough a training in the basic subjects of this field.

As mathematics is such an old science and as there is such a close relation between various fields, it might be supposed that fields of research would lie in remote and almost inaccessible parts of this subject. It must be confessed that this view is not without some foundation, but these are days of rapid transportation and the student starts early on his mathematical journey. The question as regards the extent of explored country which should be studied before entering unexplored regions is a very perplexing one. A lifetime would not suffice to become acquainted with all the known fields, and there are those who are so much attracted by the explored regions that they do not find time or courage to enter into the unknown.

In 1840 C. G. J. Jacobi used an illustration, in a letter[4] to his brother, which may serve to emphasize an important point. He states that at various times he had tried to persuade a young man to begin research in mathematics, but this young man always excused himself on the ground that he did not yet know enough. In answer to this statement Jacobi asked this man the following question: Suppose your family would wish you to marry, would you then

[2] "Encyclopédie des sciences mathematiques," Vol. I., part 1, 1904, p. 2.

[3] "Der Urquell aller Mathematik sind die ganzen Zahlen, Minkowski, Diophantische Approximation," 1907, preface.

[4] "Briefwechsel zwischen C. G. J. Jacobi und M. H. Jacobi," 1907, p. 64.

also reply that you did not see how you could marry now, as you had not yet become acquainted with *all* the young ladies?

In connection with this remark by Jacobi we may recall a remark by another prominent German mathematician who also compared the choice of a subject of research with marriage. In the "Festschrift zur Feier des 100 Geburtstages Eduard Kummers," 1910, page 17, Professor Hensel states that Kummer declined, as a matter of principle, to assign to students a subject for a doctor's thesis, saying that this would seem to him as if a young man would ask him to recommend to him a pretty young lady whom he should marry.

While it may not be profitable to follow these analogies into details, it should be stated that the extent to which a subject has been developed does not necessarily affect adversely its desirability as a field of research. The greater the extent of the development the more frontier regions will become exposed. The main question is whether the new regions which lie just beyond the frontier are fertile or barren. This question is much more important than the one which relates to the distance that must be traveled to reach these new fields. Moreover, it should be remembered that mathematics is n-dimensional, n being an arbitrary positive integer, and hence she is not limited, in her progress, to the directions suggested by our experiences.

If we agree with Minkowski that the integers are the source of all mathematics[5] we should remember that the numbers which have gained a place among the integers of the mathematician have increased wonderfully during recent times. According to the views of the people who preceded Gauss, and according to the elementary mathematics of the present day, the integers may be represented by points situated on a straight line and separated by definite fixed distance. On the other hand, the modern mathematician does not only fill up the straight line with algebraic integers, placing them so closely together that between any two of them there is another, but he fills up the whole plane equally closely with these integers. If our knowledge of mathematics had increased during the last two centuries as greatly as the number of integers of the mathematician we should be much beyond our present stage. The astronomers may be led to the conclusion that the universe is probably finite from the study of the number of stars revealed by telescopes of various powers, but the mathematician finds nothing which seems to contradict the view that his sphere of action is infinite.

From what precedes one would expect that the number of fields of mathematical research appears unlimited and this may serve to furnish a partial explanation of the fact that it seems impossible to give a complete definition of the term mathematics. If the above view is correct we have no reason to expect that a complete definition of this term will ever be possible, although it seems possible that a satisfactory definition of the developed parts may be forthcoming.[6]

Among the various fields of research those which surround a standing problem are perhaps most suitable for a popular exposition, but it should not be inferred that these are necessarily the most important points of attack for the young inves-

[5] This view was expressed earlier by Kronecker, who was the main founder of the school of mathematicians who aim to make the concept of the positive integers the only foundation of mathematics. Cf. Klein und Schimmack, "Der mathematische Unterricht an den hoeheren Schulen," 1907, p. 175.

[6] Bôcher discussed some of the proposed definitions in the *Bulletin of the American Mathematical Society*, Vol. II. (1904), p. 115.

tigator. On the contrary, one of the chief differences between the great mathematician and the poor one is that the former can direct his students into fields which are likely to become well known in the near future, while the latter can only direct them to the well-known standing problems of the past, whose approaches have been tramped down solid by the feet of the mediocre, who are often even too stupid to realize their limitations. The best students can work their way through this hard crust, but the paddle of the weaker ones will only serve to increase its thickness if it happens to make any impression whatever.

It would not be difficult to furnish a long list of standing mathematical problems of more or less historic interest. Probably all would agree that the most popular one at the present time is Fermat's greater theorem. In fact, this theorem has become so popular that it takes courage to mention it before a strictly mathematical audience, but it does not appear to be out of place before a more general audience like this.

The ancient Egyptians knew that $3^2 + 4^2 = 5^2$ and the Hindus knew several other such triplets of integers at least as early as the fourth century before the christian era.[7] These triplets constitute positive integral solutions of the equation

$$x^2 + y^2 = z^2.$$

Pythagoras gave a general rule by means of which one can find any desired number of such solutions, and hence these triplets are often called Pythagorean numbers. Another such rule was given by Plato, while Euclid and Diophantus generalized and extended these rules.

Fermat, a noted French mathematician of the seventeenth century, wrote on the margin of a page of his copy of Diophantus the theorem that it is impossible to find any positive integral solution of the equation

$$x^n + y^n = z^n \qquad (n > 2).$$

He added that he had discovered a wonderful proof of this theorem, but that the margin of the page did not afford enough room to add it.[8] This theorem has since become known as Fermat's greater theorem and has a most interesting and important history, which we proceed to sketch.

About a century after Fermat had noted this theorem Euler (1707–1783) proved it for all the cases when n is a multiple of either 3 or 4, and, during the following century, Dirichlet (1805–1859) and Legendre (1752–1833) proved it for all the cases when n is a multiple of 5. The most important step towards a general proof was taken by Kummer (1810–1893), who applied to this problem the modern theory of algebraic numbers and was thus able to prove its truth for all multiples of primes which do not exceed 100 and also for all the multiples of many larger primes.

The fact that such eminent mathematicians as Fermat, Euler, Dirichlet, Legendre and Kummer were greatly interested in this problem was sufficient to secure for it considerable prominence in mathematical literature, and several mathematicians, including Dickson, of Chicago, succeeded in extending materially some of the results indicated above. The circle of those taking an active interest in the problem was suddenly greatly enlarged, a few years ago, when it become known that a prize of 100,000 Marks (about $25,000) was awaiting the one who could present the first complete solution. This amount was put in trust of the Göttingen Gesellschaft der

[7] Lietzmann, "Der Pythagoreische Lehrsatz," 1912, p. 52.

[8] Fermat's words are as follows: "Cujus rei demonstrationem mirabilem sane detexi. Hanc marginis exiguitas non caperet."

Wissenschaften by the will of a deceased German mathematician named Wolfskehl, and it is to remain open for about a century, until 2007, unless some one should successfully solve the problem at an earlier date.

It is too early to determine whether the balance of the effects of this prize will tend towards real progress. One desirable feature is the fact that the interest on the money is being used from year to year to further important mathematical enterprises. A certain amount of this has already been given to A. Wieferich for results of importance towards the solution of Fermat's problem, and other amounts were employed to secure at Göttingen courses of lectures by Poincaré and Lorentz.

What appears as a bad effect of this offered prize is the fact that many people with very meager mathematical training and still less ability are wasting their time and money by working out and publishing supposed proofs. The number of these is already much beyond 1,000 and no one can foresee the extent to which this kind of literature will grow, especially if the complete solution will not be attained during the century. A great part of this waste would be eliminated if those who would like to test their ability along this line could be induced to read, before they offer their work for publication, the discussion of more than 100 supposed proofs whose errors are pointed out in a German mathematical magazine called *Archiv der Mathematik und Physik,* published by B. G. Teubner, of Leipzig. A very useful pamphlet dealing with this question is entitled, "Ueber das letzte Fermatische Theorem, von B. Lind," and was also published by B. G. Teubner, in 1910.

A possible good effect of the offered prize is that it may give rise to new developments and to new methods of attack. As the most successful partial solution of the problem was due to the modern theory of algebraic numbers, one would naturally expect that further progress would be most likely to result from a further extension of this theory, or, possibly, from a still more powerful future theory of numbers. If such extensions will result from this offer they will go far to offset the bad effect noted above, and they may leave a decided surplus of good. Such a standing problem may also tend to lessen mathematical idolatry, which is one of the most serious barriers to real progress. We should welcome everything which tends to elevate the truth above our idols formed by men, institutions or books.

In view of the fact that the offered prize is about $25,000 and that lack of marginal space in his copy of Diophantus was the reason given by Fermat for not communicating his proof, one might be tempted to wish that one could send credit for a dime back through the ages to Fermat and thus secure this coveted prize and the wonderful proof, if it actually existed. This might, however, result more seriously than one would at first suppose; for if Fermat had bought on credit a dime's worth of paper even during the year of his death, 1665, and if this bill had been drawing compound interest at the rate of six per cent. since that time, the bill would now amount to more than seven times as much as the prize. It would therefore require more than $150,000, in addition to the amount of the prize, to settle this bill now.

While it is very desirable to be familiar with such standing problems as Fermat's theorem, they should generally be used by the young investigator as an indirect rather than as a direct object of research. Unity of purpose can probably not be secured in any better way than by keeping

in close touch with the masters of the past,[9] and this unity of purpose is almost essential to secure real effective work in the immense field of mathematical endeavor. As a class of problems which are much more suitable for direct objects of research on the part of those who are not in close contact with a master in his field, we may mention the numerous prize subjects which are announced from year to year by foreign academies.

Among the learned societies which announce such subjects the Paris Academy of Sciences is probably most widely known, but there are many others of note. The subjects announced annually by these societies cover a wide range of mathematical interests, but they are frequently beyond the reach of the young investigator.[10] It is very easy to obtain these subjects, since they generally appear in the "notes" of many mathematical journals. In our country the *Bulletin of the American Mathematical Society* is rendering very useful service along this and many other lines. While some of these subjects are very general, there are others which indicate clearly the particular difficulties which must be overcome before further progress in certain directions seems possible and hence these subjects deserve careful study, especially on the part of the younger investigators.

As long as one is completely guided, in selecting subjects for research, by the standing problems or by the subjects announced by learned bodies and those proposed individually by prominent investigators, one is on safe ground. Real progress along any of these lines is welcomed by our best journals, as such progress can easily be measured, and it fits into a general trend of thought which is easily accessible in view of the many developed avenues of approach. Notwithstanding these advantages, the real investigator should reach the time when he can select his own problems without advice or authority; when he feels free to look at the whole situation from a higher point of view and to assume the responsibility of an independent choice, irrespective of the fact that an independent choice may entail distrust and misgivings on the part of many who would have supported him nobly if he had remained on their plane.

In looking at the whole situation from this higher point of view many new and perplexing questions confront us. Why should the developments of the past have followed certain routes? What is the probability that the development of the territory lying between two such routes will exhibit new points of contact and greater unity in the whole development? What should be some guiding principles in selecting one rather than another subject of investigation? What explanation can we give for the fact that some regions bear evidences of great activity in the past but are now practically deserted, while others maintained or increased their relative popularity through all times?

One of the most important tests that can be applied to a particular mathematical theory is whether it serves as a unifying and clarifying principle of wide applications. Whether these applications relate to pure mathematics only or to related fields seems less important. In fact, the subjects of application may have to be developed. If this is the case, it is so much the better provided always that the realm of thought whose relations are exhibited by the theory is extensive and that the relations are of such a striking character as to

[9] Darboux, *Bulletin des Sciences Mathématiques*, Vol. 32 (1908), p. 107.

[10] For solutions of such problems in pure mathematics by Americans, see *Bulletin of the American Mathematical Society*, Vol. 7 (1901), p. 190; Vol. 16 (1910), p. 267.

appeal to a large number of mathematical intellects of the present or of the future. Some isolated facts may be of great interest, but as long as they are isolated they have little or no real mathematical interest. One object of mathematics is to enable us to deal with infinite sets with the same ease and confidence as if they were individuals. In this way only can our finite mind treat systematically some of the infinite sets of objects of mathematical thought.

In comparatively recent years the spirit of organization has made itself felt among mathematicians with rapidly increasing power, and it has already led to many important results. Beginning with small informal organizations in which the social element was often most prominent, there have resulted large societies, national and even international, with formal organizations and with extensive publications. In reference to one of these early organizations, the mathematical society of Spitalfields in London, which lasted for more than a century (1717–1845), it is said that each member was expected to come to the meetings with his pipe, his mug and his problem.[11]

The modern mathematical society is dominated by a different spirit. It generally supports at least one organ for publication, and scholarly publicity develops scholarly cooperation as well as scholarly ambitions. This cooperation has led to movements which could not have been undertaken by a few individuals. One may recall here the *Revue Semestrielle,* published under the auspices of the Amsterdam Mathematical Society; the extensive movement to examine and compare methods and courses of mathematical instruction in various countries, inaugurated at the fourth international congress, held at Rome in 1908; and, especially the great mathematical encyclopedias whose start was largely influenced by the support of the deutschen Mathematiker-Vereinigung as expressed at the Vienna meeting in 1894. The French edition of the latter work, which is now in the course of publication, is expected to include thirty-four large volumes, besides those which are to be devoted to questions of the philosophy, the teaching and the history of mathematics.

These encyclopedias and other large works of reference are doing much to expedite travel in the mathematical field. In fact, it would probably not be exaggerating if we should say that by these encyclopedias alone the distances, in time and effort, between many points of the mathematical field have been cut in two. In this connection, it may be fitting to recall, with a deep sense of obligation, the great work which is being done by the Royal Society of London—not only for mathematics, but also for a large number of other sciences—in providing bibliographical aids on a large scale. If the increase in knowledge will always be attended by a corresponding increase in means to learn readily what is known, even the young investigator of the future will have no reason to regret the extent of the developments. On the contrary, these should make his task easier, since they furnish such a great richness of analogies and of tried methods of attack.

The last two or three decades have witnessed a great extension of mathematical research activity. As a result of this we have a large number of new mathematical societies. A few of the most recent ones are as follows: Calcutta Mathematical Society (1908), Manchester Mathematical Society (1908), Scandinavian Congress of Mathematicians (1909), Swiss Mathemat-

[11] "Es wurde von jedem erwartet, dass er seine Pfeife, seinen Krug und sein Problem mitbringe." Cantor, "Vorlesungen ueber Geschichte der Mathematik," Vol. 4, 1908, p. 59.

ical Society (1910), Spanish Mathematical Society (1911) and the Russian Congress of Mathematicians (1912). In Japan a new mathematical periodical, called *Tôhoku Mathematical Journal,* was started in 1911, and a few years earlier the *Journal of the Indian Mathematical Society* was started at Madras, India. The Calcutta Mathematical Society and the Spanish Mathematical Society have also started new periodicals during the last two or three years.

While there has been a very rapid spread of mathematical activity during recent years, it must be admitted that the greater part of the work which is being done in the new centers is quite elementary from the standpoint of research. The city of Paris continues to hold its preeminent mathematical position among the cities of the world; and Germany, France and Italy continue to lead all other countries in regard to the quality and the quantity of research in pure mathematics.

Although America is not yet doing her share of mathematical research of a high order, we have undoubtedly reached a position of respectability along this line, and it should be easier to make further progress. Moreover, our material facilities are increasing relatively more rapidly than those of the countries which are ahead of us, and hence many of our younger men start under very favorable conditions. Unfortunately, there is not yet among us a sufficiently high appreciation of scholarly attainments and scientific distinction. The honest and outspoken investigator is not always encouraged as he ought to be and the best positions do not always seek the best man. I coupled outspoken with investigator advisedly, since research of high order implies liberty and scorns shams, especially shams relating to scholarship. Even along these lines there seems to be encouraging progress, and this progress may reasonably be expected to increase with the passing of those who belong to the past in spirit and attainments. What appears to be a very serious element in our situation is the fact that the American university professor does not yet seek and safeguard his freedom with the zeal of his European colleague. It is too commonly assumed that loyalty implies lying.

The investigators in pure mathematics form a small army of about two thousand men and a few women.[12] The question naturally arises what is this little army trying to accomplish. A direct answer is that they are trying to find and to construct paths and roads of thought, which connect with or belong to a network of thought roads commonly known as mathematics. Some are engaged in constructing trails through what appears an almost impassable region while others are widening and smoothing roads which have been traveled for centuries. There are others who are engaged in driving piles in the hope of securing a solid foundation through regions where quicksand and mire have combined to obstruct progress.

A characteristic property of mathematics is that by means of certain postulates its

[12] Between five and ten per cent. of the members of the American Mathematical Society are women, but the per cent. of women in the leading foreign mathematical societies is much smaller. Less than one per cent. of the members of the national mathematical societies of France, Germany and Spain are women, according to recent lists of members. The per cent. of important mathematical contributions by women does not appear to be larger, as a rule, than that of their representation in the leading societies. The list of about three hundred collaborators on the great new German and French mathematical encyclopedias does not seem to include any woman. Possibly women do not prize sufficiently intellectual freedom to become good mathematical investigators. Some of them exhibit excellent ability as mathematical students.

thought roads have been proved to be safe and they always lead to some prominent objective points. Hence they primarily serve to economize thought. The number of objects of mathematical thought is infinite, and these roads enable a finite mind to secure an intellectual penetration into some parts of this infinitude of objects. It should also be observed that mathematics consists of a *connected* network of thought roads, and mathematical progress means that other such connected or connecting roads are being established, which either lead to new objective points of interest or exhibit new connections between known roads.

The network of thought roads called mathematics furnishes a very interesting chapter in the intellectual history of the world, and in recent years an increasing number of investigators have entered the field of mathematical history. The results are very encouraging. In fact, there are very few other parts of mathematics where the progress during the last twenty years has been as great as in this history. This progress is partly reflected by special courses in this subject in the leading universities of the world. While the earliest such course seems to have been given only about forty years ago, a considerable number of universities are now offering regular courses in this subject, and these courses have the great advantage that they establish another point of helpful contact between mathematics and other fields.

Mathematical thought roads may be distinguished by the facts that by means of certain assumptions they have been *proved* to lead safely to certain objective points of interest, and each of them connects, at least in one point, with a network of other such roads which were called mathematics, *μαθήματα* by the ancient Greeks. The mathematical investigator of the present day is pushing these thought roads into domains which were totally unknown to the older mathematicians. Whether it will ever be possible to penetrate all scientific knowledge in this way and thus to unify all the advanced scientific subjects of study under the general term of mathematics, as was the case with the ancient Greeks,[13] is a question of deep interest.

The scientific world has devoted much attention to the collection and the classification of facts relative to material things, and has secured already an immensely valuable store of such knowledge. As the number of these facts increases, stronger and stronger means of intellectual penetration are needed. In many cases mathematics has already provided such means in a large measure; and, judging from the past, one may reasonably expect that the demand for such means will continue to increase as long as scientific knowledge continues to grow. On the other hand, the domain of logic has been widely extended through the work of Russell, Poincaré and others; and Russell's conclusion that any false proposition implies all other propositions whether true or false is of great general interest.

During the last two or three centuries there has been a most remarkable increase in facilities for publication. Not only have academies and societies started journals for the use of their members, but numerous journals inviting suitable contributions from the public have arisen. The oldest of the latter type is the *Journal des Sçavans,* which was started at Paris in 1665, while the *Transactions of the Royal Society of London,* started in the same year, should probably be regarded as the oldest of the former type. These journals have done an

[13] The term mathematics was first used with its present restricted meaning by the Peripatetic School. Cantor, "Vorlesungen über Geschichte der Mathematik," Vol. I. (1907), p. 216.

inestimable amount of good for the growth of knowledge and the spread of the spirit of investigation. At the present time more than 2,000 articles which are supposed to be contributions to knowledge in pure mathematics appear annually in such periodicals. In addition to these there is a growing annual list of books.

The great extent of the fields of mathematics and the rapid growth of this literature have made it very desirable to secure means of judging more easily the relative merit of various publications. Along this line our facilities are still very meager and many serious difficulties present themselves. In America we have the book reviews and the indirect means provided by the meetings of various societies and by such publications as the "American Men of Science."

The most important aid to judge contemporaneous work is furnished by a German publication known as the *Jahrbuch über die Fortschritte der Mathematik*. In this work there appear annually about 1,000 pages of reviews of books and articles published two or three years earlier. These reviews are prepared by about 60 different mathematicians who are supposed to be well prepared to pass judgment on the particular books and articles which they undertake to review. While these reviews are of very unequal merit, they are rendering a service of the greatest value.

The main object of such reviews is to enable the true student to learn easily what progress others are making, especially in his own field and in those closely related thereto. They serve, however, another very laudable purpose in the case that they are reliable. We have the pretender and the unscrupulous always with us, and it is almost as important to limit their field of operation as to encourage the true investigator. "Companions in zealous research" should be fearless in the pursuit of truth and in the disclosure of falsehood, since these qualities are essential to the atmosphere which is favorable to research.

While the mathematical investigator is generally so engrossed by the immediate objects in view that he seldom finds time to think of his services to humanity as a whole, yet such thoughts naturally come to him more or less frequently, especially since his direct objects of research seldom are well suited for subjects of general conversation. If these thoughts do come to him they should bring with them great inspiration. Who can estimate the amount of good mathematics has done and is doing now? If all knowledge of mathematics could suddenly be taken away from us there would be a state of chaos, and if all those things whose development depended upon mathematical principles could be removed, our lives and thoughts would be pauperized immeasurably. This removal would sweep away not only our modern houses and bridges, our commerce and landmarks, but also most of our concepts of the physical universe.

Some may be tempted to say that the useful parts of mathematics are very elementary and have little contact with modern research. In answer we may observe that it is very questionable whether the ratio of the developed mathematics to that which is finding direct application to things which relate to material advantages is greater now than it was at the time of the ancient Greeks. The last two centuries have witnessed a wonderful advance in the pure mathematics which is commonly used.[14] While the advance in the extent

[14] In 1726, arithmetic and geometry were studied during the senior year in Harvard College. Natural philosophy and physics were still taught before arithmetic and geometry. Cajori, "The Teaching and History of Mathematics in the United States," 1890, p. 22.

of the developed fields has also been rapid, it has probably not been relatively more rapid. Hence the mathematical investigator of to-day can pursue his work with the greatest confidence as regards his services to the general uplift both in thought and in material betterment of the human race. All of his real advances may reasonably be expected to be enduring elements of a structure whose permanence is even more assured than that of granite pillars.

G. A. MILLER

UNIVERSITY OF ILLINOIS

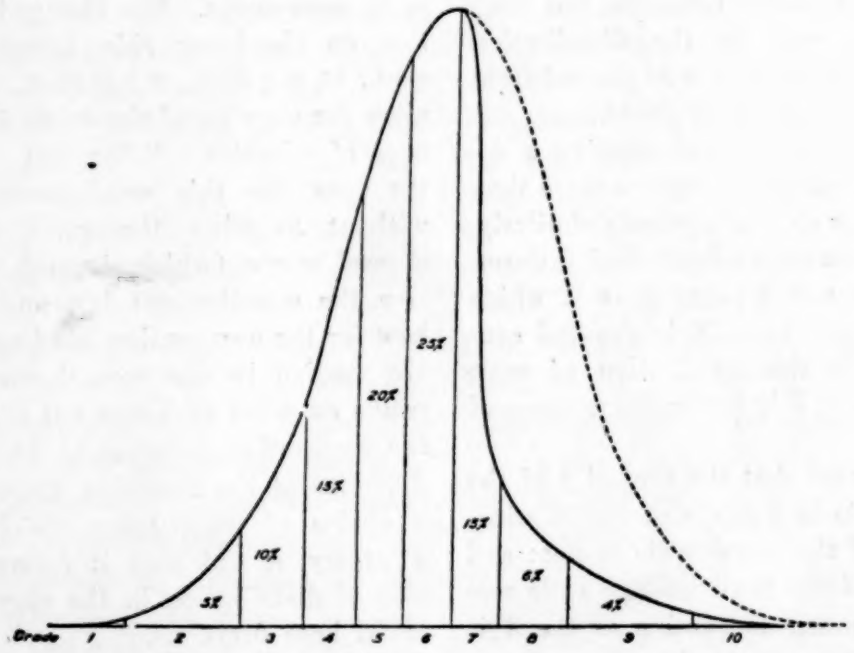
SCIENTIFIC DISTRIBUTION OF GRADES AT REED COLLEGE

A SCIENTIFIC rather than a personal basis for awarding grades in courses of study, if grades are to be used at all, together with definite credit for quality as well as for quantity of work, seems desirable, especially for institutions that are more than theoretically devoted to scholarship, and that are willing to make what sacrifices such ideals may involve.

The common grades *A* to *E* have no defined meaning. To call them such and such a per cent. of an undefined something is to substitute one vague expression for another. Without scientific definition, any set of symbols is inevitably used in personal, variable, erratic ways. To award scholarships, degrees and other honors, as if an *A* in one course represented the same distinction as an *A* in another course is to administer the curriculum on a patently false assumption.[1]

Until all school work can be measured by scales, made up of units that are equal in a defined sense, the best available grading is one of relative position in a series. The nearest approach to such a scientific basis for awarding college credits appears to be a distribution following the normal probability curve, skewed to take account of the effect of selecting the student body.

The Reed College system is shown in the illustration. The outer curve, partly dotted, is the normal probability curve. The inner curve, partly coinciding with the other, shows



[1] It is impossible, here, to give a detailed explanation of the "credit for quality" system and the scientific distribution of grades adopted by Reed College. The underlying principles of both are fully explained in chapters 12 and 13 of the "Administration of the College Curriculum," Houghton Mifflin Company, 1911. "The Distribution of Grades on a Scientific Basis" is presented in *Popular Science Monthly* for April, 1911.

the result of selecting the student body, and would be vertical at the right side if it were possible to perfect the selection so as to exclude all below a certain standard and admit all above that standard.

Reed College uses ten grades. Ten, rather than any other number, are used, because tests by approved statistical and psychological methods show that fewer grades are inadequate to designate readily discernible differences, and many more grades can not be used with intelligent discrimination. The definitions of these grades have a scientific basis. Grades 1–5 indicate that a student stands in the upper half of an average class; grades 6–10 indicate that he is in the lower half. For example, 2 designates the work which will be done (in the long run) by the best 5 per cent. of all students, and 6 the work done by that quarter of an average class standing just below the middle. These particular percentages were chosen somewhat arbitrarily for the sake of convenient round numbers, but they correspond fairly well to the distribution shown in the probability curve as skewed from normal by the selection of students.

Grade 1 is rarely given, representing a degree of excellence attainable by not more than one student in four or five hundred; similarly, grade 10 records correspondingly bad failures. The lowest grade called passable is 8, which covers all cases where credit is granted conditionally or upon the satisfaction of some special requirement; 9 is for ordinary cases of failure.

It will be observed that the symbol 1 of the Reed College scale is a grade of real distinction, as the *A* of the usual scale is not; and that even the 3 of the Reed College scale represents quite as much distinction as the *A* if the latter grade were obtained by 15 per cent. of a class.

The grades, however, can not be interpreted in qualitative terms, as good, poor, *A*, *C*, 90 per cent.; nor do they designate rank in the particular class. They show the group in which the student would appear if the classes of several years were subdivided as indicated above.

Such a definition will not make a "2" = "2" as regards the actual quality of work done by the student, since this is a matter not only of the student's relative standing in the subject, but also of the actual standards set for that subject. But despite this, for courses of the same general sort (as introductory courses without prerequisites, whether coming in freshman or senior year), the relative rank in an average class seems to be the best available criterion of the student's merits.

In adopting the Reed College System, we attempted to divide the base line of the normal probability curve into equal parts; but we found this awkward, as grade 2 would then fall to but 1½ per cent. of the students. We then tried (each side of the median) a distribution of 20 per cent., 15 per cent., 10 per cent., 5 per cent., which corresponds to equal bases for grades 4, 5, 6, 7 with somewhat longer bases for 3 and 8, and much longer ones for 2 and 9. This distribution seemed more convenient. We changed the distribution on the lower side, however, to 25 per cent., 15 per cent., 6 per cent., 4 per cent., to allow for skewing of the curve due to the influence of selection. What sort of divisions of the base line this requires no one can say without knowing the exact shape of the skewed curve (which depends on how effective the selective cut is), and knowing also how far the new median has been moved above the median in the normal curve (which depends on what area was cut off, according to the standard of selection). In using unequal divisions of the base line, therefore, we make a choice of percentages which is somewhat arbitrary, except that it follows roughly the sort of distribution in the skewed curve with equal base divisions.

With such a basis for grading students in their college courses, it is possible to give a definite and just reward for high scholarship by allowing a course completed with high credit to count more toward a degree than a course completed with lower credit. Such a plan for counting quality has the great advantage of enabling the students who do the best work to graduate in less than the normal

time, without tempting them to take more subjects in a given year than they can creditably pursue.

WILLIAM T. FOSTER

SCIENTIFIC NOTES AND NEWS

BY the untimely death of Wilbur Wright the country loses an inventor of distinction, whose great achievement in the development of the aeroplane gives him high rank among those who have contributed to the practical applications of science.

DR. WILLIAM MCMICHAEL WOODWORTH, of the Harvard Museum of Comparative Zoology and the author of important contributions to zoology, has died at the age of forty-eight years.

VICE-PRESIDENT THOMAS JONATHAN BURRILL and Comptroller Samuel Walker Shattuck, of the University of Illinois, will retire from active service at the end of the present academic year, having been granted special retiring allowances by the Carnegie Foundation for the Advancement of Teaching. Both of them have been with the university since its foundation in 1868, and have been potent factors in its upbuilding. Dr. Burrill has served as professor, dean, vice-president and acting president and has done notable research work in botany and bacteriology. Professor Shattuck has served as professor of mathematics, vice-president and comptroller.

DR. HENRY T. EDDY, head of the department of mathematics and mechanics at the University of Minnesota and dean of the graduate school, will retire from active service under the terms of the Carnegie Foundation.

PROFESSOR THEODORE W. RICHARDS, of the department of chemistry of Harvard University, lectured at the University of Michigan upon "Atomic Compressibility" on May 16. On May 17 he was awarded the Willard Gibbs medal by the Chicago Section of the American Chemical Society, and delivered an address upon "Atomic Weights."

THE death of Lord Lister having created a vacancy in the membership of the Royal Society of Science, Upsala, Sir Victor Horsley, F.R.S., has been elected his successor.

THE Société Astronomique de France has, says *The Observatory,* lately taken advantage of two anniversaries to pay honor to the founder and past-president of the society. January 28 last was the twenty-fifth anniversary of the founding of the society, and this year is the fiftieth of M. Flammarion's career as an astronomical writer, for his first great work, "La Pluralité des Mondes habités," was published in 1862. The actual ceremony took place in the large hall of the Sociétés Savants on the evening of February 26, which happened to be M. Flammarion's seventieth birthday, so that three anniversaries were celebrated.

As a memorial of Professor Ralph S. Tarr a volume is to be published consisting of essays on physiographic and geographic subjects, the work of men trained by him. A committee has been named to take charge of the preparation and publication of the volume. This committee has asked Dr. Frank Carney, professor of geology in Denison University, to edit the work.

THE completion by Rudolf von Jaksch of twenty-five years as professor of internal medicine at Prague was celebrated recently. The *Prager med. Wochenschrift* issued a special number in his honor and a *Festschrift* was presented to him.

COLONEL SIR DAVID BRUCE, C.B., F.R.S., has been promoted to the rank of surgeon general in the British Army, in consideration of his eminent services to the cause of science. Sir David Bruce is at present at the head of the Sleeping Sickness Commission appointed by the government, with the advice of the Royal Society, to continue the study of the disease in Nyasaland.

A GRANT of $140 from the C. M. Warren Fund of the American Academy of Arts and Sciences has been made to Professor Arthur B. Lamb for work upon the rhodiumamines.

HARRY MILES JOHNSON, Ph.D. (Hopkins '12), has been appointed psychological assistant in the physical laboratory of the National Electric Lamp Association, Cleveland, Ohio.

THE American Road Builders' Association gave a dinner at the Hotel Astor, New York

City, on June 5, in honor of W. Rees Jeffreys, Esq., secretary of the road board of England and honorary general secretary of the local organizing committee of the third International Road Congress to be held in London in June, 1913.

Professor Thomas A. Jaggar, Jr., professor of geology in the Massachusetts Institute of Technology, has been granted leave of absence for five years, and sails for Honolulu early this month to take charge of the Volcano Laboratory of the institute on the crater of Kilauea. Drs. A. L. Day and E. S. Shepherd, of the Carnegie Institution, are now in Hawaii and expect to spend the summer in investigations of optical pyrometry and spectroscopic analysis.

Professor Ellsworth Huntington, of Yale University, will this year carry further the work of investigating climatic changes during the last two or three thousand years which he undertook last summer under the auspices of the Carnegie Institute of Washington. Accompanied by Professor H. S. Canby, he has left for California, where he will be joined by a party of four or five students and others from the University of California. They will proceed into the Sierra Nevada Mountains in the King's River section south of Yosemite, where they will spend two months measuring trees.

Professor Alfred Dodge Cole, head of the department of physics at Ohio State University, has been granted leave of absence for the college year 1912–13. It is probable that he will spend four months in research at the National Bureau of Standards, Washington, and a semester similarly at the University of Berlin.

Dr. Albert Bushnell Hart, professor of the science of government at Harvard University, is at present lecturing at Colorado College in Colorado Springs as exchange professor. He is giving lectures on American history (1850–1865), on American biography, and on the Orient (Japan, China, Philippines, India).

The Harrington lectures arranged by the medical faculty of the University of Buffalo will be delivered in Alumni Hall by Dr. Ludvig Hektoen, of Chicago, on May 28 to 31, on "Immunity."

Professor C. A. Adams, of Harvard University, gave a lecture "On the Place of the Engineer in Modern Society," at the University of Vermont on the evening of May 15, and a lecture on "The Synchronous Motor," on the morning of May 16.

The Illinois State Association of Operating Engineers met at the University of Illinois on May 24. Addresses were given by President James, Dean W. F. Goss, of the College of Engineering, Professor Parr and Professor Bartow, of the department of chemistry.

A conference will be held at the Graduate School of Agriculture, Lansing, Mich., on July 24, to discuss the formulation of standard rations for experimental work in determining the comparative value of feed stuffs. Mr. B. H. Rawl, chief of the dairy division, U. S. Department of Agriculture, President H. J. Waters, of the Kansas Agricultural College, Professor C. H. Eckles, of the Missouri Experiment Station, and other leading workers in this field are expected to be present and lead the discussion.

All persons interested in the scientific section of the American Pharmaceutical Association are requested to notify any of the officers of the section of the title or titles of the paper or papers that they contemplate presenting before the section at the annual meeting of the Association at Denver, Colorado, August 19–24 inclusive, 1912. Original papers of scientific interest, whether directly of pharmaceutical interest or not will be considered by the committee. The committee on scientific papers consists of W. O. Richtmann, *chairman;* F. P. Stroup, *secretary,* 145 North 10th St., Philadelphia, Pa.; F. R. Eldred, associate, 3323 Kenwood Ave., Indianapolis, Ind.

The second annual meeting of the American Climatological Association will be held in Hartford, Conn., June 10–12, under the presidency of Dr. A. D. Blackader, Montreal.

The conference of bath officials and others interested in public baths, held at New York City, on May 14 and 15, resulted in the or-

ganization of the American Association for Promoting Hygiene and Public Baths. Dr. Simon Branch, professor in the medical department of Columbia University, who has for nearly twenty years led the movement for free public baths, was elected president, and Dr. William H. Hale, permanent secretary. The annual meeting will be held on the second Tuesday of May, the next meeting being at Baltimore, May 13, 1913. The membership fee is one dollar a year and all persons of good character are eligible for membership.

A CABLEGRAM received at the Harvard College Observatory from Kiel states that a spectrogram of Enebos Nova obtained by Kuestner at Bonn shows "dark lines uranium radium emanation."

WE learn from the London *Times* that Messrs. Sotheby sold, on May 17, the scientific books of the late Sir Joseph Dalton Hooker, among which were several presentation copies, whilst many were with valuable MS. notes by the late owner. A set of Hooker's *Icones Plantarum*, 1837–1911, 30 volumes—£67 (Wesley); Edwards's *Botanical Register*, 1815–47, 33 volumes—£26 (Muller); and a collection of books on the "Flora" of the Antarctic regions, New Zealand, etc., in nine volumes—£123 (Wesley). The late Dr. Joseph F. Payne's property included a slightly defective copy of Apuleius Platonicus, "Herbarium," Rome, 1488, the earliest printed book with figures of plants—£55 (Leighton); J. Milton, "Areopagitica," 1644, the very rare first edition, one page slightly cut into—£21 (Barnard); and Joannem de Cuba, "Tractatus de Herbis," etc., 1491, with numerous woodcuts of plants and animals, slightly defective—£35 (Quaritch). The two days' sale of books realized £1,488 14s.

ACCORDING to the *Journal* of the American Medical Association the births for 1910 were 35,119 and for 1911, 69,098 below the average for the decade 1901 to 1910, while the number of marriages in the first year was 10,154 and in the latter 20,897 above the average in that period. It is therefore evident that the fertility of married women has shown a considerable decrease. For each 1,000 of the population there occurred in 1911 30.2 births as compared with 31.5 in 1910, 32.7 in 1909, 33.7 in 1908 and 37.4 in 1901, so that in ten years the birth rate has dropped by 7.2 per thousand. The number of deaths in 1911 was 18.1 per thousand, as contrasted with 16.9, 17.9, 18.9 and 21.7 in the four preceding years. According to these figures, the excess of births for 1911 was 12.1, as compared with 14.6 in 1910, 14.8 in 1909 and 1908 and 15.7 in 1901.

UNIVERSITY AND EDUCATIONAL NEWS

NEARLY $1,000,000 was appropriated by the General Education Board at its meeting on May 24. $250,000 is given to the George Peabody College for Teachers at Nashville, Tenn., for the establishment of the Seaman A. Knapp School of Country Life. The other colleges awarded conditional appropriations are: Beloit College, Beloit, Wis., $100,000; Coe College, Cedar Rapids, La., $100,000; McAlester College, St. Paul, Minn., $50,000; University of Rochester, Rochester, N. Y., $200,000. The sum of $210,000 was set aside for demonstration work in agriculture in the southern states, for professors of secondary education in state universities of the south, and to aid the work of Negro education in the south.

PROFESSOR OTIS F. RANDALL, who holds the chair of mechanics and mechanical drawing at Brown University, has been appointed dean of the university to succeed Professor Alexander Meiklejohn, who is to become president of Amherst College.

DR. GEORGE DOCK has resigned the deanship of the medical department of Washington University, St. Louis. Dr. Dock will continue as professor of medicine.

DR. DAVID RIESMAN and Dr. Joseph Sailer have been elected professors of clinical medicine in the medical department of the University of Pennsylvania, in succession to the late Dr. John H. Musser. Dr. Richard M. Pearce occupies the John Herr Musser professorship of medical research.

VICTOR C. MYERS, Ph.D. (Yale, '09), has been appointed professor of pathological chemistry, and has taken charge of the new labora-

tory for pathological chemistry recently opened at the New York Post-Graduate Medical School and Hospital.

Professor William E. Brooke, of the College of Engineering, University of Minnesota, has been appointed to fill the vacancy caused by the retirement of Dr. H. T. Eddy, the head of the department of mathematics and mechanics. Dr. William F. Holman takes the place made vacant by the retirement of Dr. Arthur E. Haynes, from the department of mathematics.

Throop Polytechnic Institute, of Pasadena, California, is materially enlarging its department of chemistry with a view to keeping in touch with the industrial development of southern California, especially in connection with the oil industry. Dr. Richard Sidney Curtiss, Ph.B. (Yale, '88), Ph.D. (Würzburg, '92), now professor of organic chemistry at the University of Illinois, has been appointed professor of organic chemistry and research associate. Charles Andrew Brautlecht, Ph.B. (Yale, '06), now doing graduate work at Yale, has been appointed instructor in chemistry and physics. William Ruthven Flint, A.B. (Yale, '98), Ph.D. (Yale, '09), continues in the department as professor of inorganic and analytical chemistry.

Owing to the rapidly growing interest in the science of chemistry and the recognition of its importance in the development of the state resources, the president and regents of the University of California have provided for the enlargement and reorganization of the department of chemistry. In addition to the present staff, the following appointments have been made: Professor Gilbert N. Lewis, of the Massachusetts Institute of Technology, professor of chemistry and chairman of the department; Professor William C. Bray, of the same institution, and Professor Richard C. Tolman, of the University of Cincinnati, assistant professors of chemistry. Several additional instructorships and assistantships have also been created. Owing to the absence of Professor Morgan, the course in elementary chemistry will be in charge of Professor Harry W. Morse, who has received for this purpose leave of absence for one year from Harvard University. Professor Edmond O'Neill has been appointed director of the chemical laboratory. Owing to the crowded condition of the present laboratory, a new building on the site provided in the Hearst plans will soon be begun. In the mean time, a temporary building is being constructed, and will contain a laboratory of physical chemistry, several offices and research laboratories and shops for mechanician and glass blower. Much attention will be given to the development of advanced study and research. A considerable number of men, several of whom come from other institutions, will enter next term as candidates for the doctorate. Advanced seminars will be offered in organic, inorganic and physical chemistry.

DISCUSSION AND CORRESPONDENCE

THE HEATING IN THE CULEBRA CUT

To the Editor of Science: Mr. MacDonald's interesting article on the heatings in Culebra Cut, in your issue of May 3, No. 905, is paralleled by the spontaneous combustion of bituminous coals, and even of the anthracite culm banks, owing to the oxidization of pyrite. It is a common occurrence, and is the cause of endless trouble in preserving museum specimens of pyrite in fine dissemination during damp weather.

In the case at issue the iron content proceeded from the ferro-magnesian silicates, as Mr. MacDonald has stated; but from ordinary surface oxidation, as is always the case in regions containing the black bisilicates, and as shown by the rustiness of springs and streams. The sulphur content is also generally present in lagoons as more or less dilute sulphuric acid. The presence of carbonaceous material points to a lagoon formation at Culebra Cut.

The function of iron is to be a carrier of oxygen from the air to the precipitated organic débris, changing from hydrated sesquioxide to protoxide: picked up by the above acid: again breaking up as hydrated sesquioxide, and continuing its endless rounds unless it happens to be included and imprisoned under a mass

of vegetation; when the round is stopped, the sesquioxide and the solution of sulphate in which all the ingredients are bathed are robbed of the oxygen and form pyrite.

The classic laboratory experiments show that organic animal matter acts with greater rapidity and sureness, and the resulting pseudomorphs of sphalerite, chalcopyrite, or pyrite, when a live clam is placed in a saturated solution of a sulphate of the above, are well known. We find them abundantly in nature, in the Trenton rocks as well as in the coal measures.

EDWARD H. WILLIAMS, JR.

THE CROCKER LAND EXPEDITION

TO THE EDITOR OF SCIENCE: The Crocker Land Expedition which was to have gone northward this summer under the leadership of George Borup and D. B. MacMillan, has been postponed to the summer of 1913, on account of the lamentable death of George Borup and the impracticability of finding a substitute for him in the short time remaining before the expedition was to start.

The Honorary Committee, consisting of President Henry Fairfield Osborn, Mr. Chandler Robbins, General Thomas H. Hubbard and Dr. Walter B. James, and the Committee in Charge, comprised of Dr. E. O. Hovey and Mr. H. L. Bridgman, have begun the reorganization of the expedition along such lines as circumstances may necessitate, without changing the main objects of the enterprise, as set forth in the prospectus issued in January 1912.

Colonel Borup and a number of the principal supporters of the expedition have united in the furtherance of the new plans; the expedition will be a memorial to George Borup, the young explorer who was so keenly interested in it and who was the mainspring of the original undertaking.

Mr. MacMillan's connection with the enterprise continues as heretofore, and he is utilizing the intervening time for the purpose of making additional preparation for the scientific work of the expedition.

A considerable part of the supplies and equipment had been prepared. The prepared material has been put into safe storage for use next year, while the special apparatus is being assembled at the museum. Subscriptions already made are sufficient to insure the starting of the expedition a year hence.

EDMUND OTIS HOVEY,
HERBERT L. BRIDGMAN,
Committee in Charge

UNIVERSITY CONTROL

LETTERS FROM HARVARD UNIVERSITY

I AM on the whole very pleasantly impressed, as you know, with the general constitution that has been worked out at Harvard: a bi-cameral arrangement for the general governing boards; one large academic faculty and several professional faculties for the boards of instruction; comparatively independent divisions and departments, with a considerable range of initiative within their own fields; a president who is, while powerful, still subject to a great many decidedly distinct and potent sorts of checks from alumni and from various boards. This constitution does not seem to me perfect. The president at Harvard has probably still too large a range of discretion. The result is certainly not bad; but is also still subject to further growth. The bi-cameral system (the "overseers" elected by the alumni, able to advise but not to initiate legislation, able also to veto; the "corporation," self-perpetuating and capable of initiating, but always subject to the overseers' veto), seems to me to work well but unevenly, since the overseers have their seasons of too great or too little activity, while the president is probably a little too potent in influencing the corporation legislatively. Nevertheless, I regard the result of the interaction between the "overseers" and the "corporation" as so useful in many crises, and so convenient both in calling out and in holding in check the interests of the alumni, that I can not be convinced of the value of your proposals 1 and 2, if they were regarded as contemplating a constitution intended to take the place of ours. I should say, in place of your proposal (1), that a bi-cameral governing body like ours is preferable to the

arrangement that you prefer. Let the alumni, or in state universities, perhaps some larger constituency of interested persons, elect one governing board—not one of absolute authority, but a representative and influential board, with a veto power large enough to be a significant guard, and an advisory power large enough to keep the university in touch with its public. Let there be another board, of another origin, to act as legal owner of the property. Let this board have a real, but not too potent authority as a manager of affairs. Let these two boards cooperate with mutual criticism. Then you could afford to give your president more power and dignity than you do in number (2). I do not agree that the president should be as shorn of power as you make him. Let him be reasonably limited, but not helpless. "Security, permanence, honor" are all consistent with a reasonable presidential leadership. With the spirit of your proposals (3) and (4) I am, on the whole, in sympathy, although I could not go so far as you do. I am willing, as at Harvard, to submit the appointment of officers of instruction to the veto of general governing boards; and to have those boards, as well as the faculties and other teaching "units," take part in all legislation that concerns general educational policies. A professor should have a solid tenure of office during good behavior, and should also have freedom of teaching. A department, or division, or other such small "unit" should have a large scope of discretion as to its own work. But one must keep in touch with one's alumni and one's public as to all questions of common educational policy; and this is why the legislation by general boards is needed, as well as the relative autonomy of departments and of individual teachers. You insist on the latter. To that insistence I agree; but I want the general boards to aid also in legislation. As to (5), I think that you go too far in expecting the departments or divisions to elect a senate capable of doing all their principal legislation for them. Once more—a frequent interaction with governing boards of the type of our Harvard "overseers"—boards that represent the alumni, and that can veto rather than initiate, seem to me a useful aid and check. What one wants is to get all the forces expressed in the university life, without arbitrary mutual interference, but with constant and mutual criticism, and without anarchy, although with plentiful individual freedom. On the whole that is what we have at Harvard.

I recognize the danger of your "Scylla of presidential autocracy" and "Charybdis of faculty and trustee [collective] incompetence." But I have seen so much efficiency, of the right kind, result from the lodging of great powers in the hands of a wise and able president that I am unwilling to agree, concerning this officer, that "his salary should not be larger, his position more dignified or his powers greater than those of the professor." Of course the right man for president is hard to find, and of course the wrong man is occasionally chosen. I wish that every man accepting a university presidency might do so with assurance of the opportunity to retire at any time from the office on a respectable pension; this would be a happy way out, for the president and for the university, in many unfortunate cases; but I would not see the powers of a well chosen, well qualified president stinted. On the other hand, I have seen a great president content to lay his most cherished projects before a large faculty and labor year after year to bring this faculty to his own way of thinking, convinced that in this assembly he had, on the whole, the most intelligent and the most fairminded body of men in the world, for his purposes. The deliberative habits of this faculty under the president were most exasperating to those who are fond of swift decisions in educational questions, and by common consent, as matters of general interest pressed upon us, matters of detail and routine were delegated more and more to committees or to special administrative officers. Moreover, departments or divisions, as they grew in size, assumed new functions, somewhat as they should according to your plan. But through all these changes, a faculty remained a fairly coherent body, mem-

bers generally, old and young, feeling that, when certain questions of general policy were up, each man of them was expected to do his duty, though comparatively few, as a rule, took an active part in the debates. Furthermore, the frequent faculty meetings, though they did not by any means make every member know every other member, tended advantageously toward general acquaintance, and individuals who, from temperament or from departmental affiliations, must differ, could at least differ more intelligently than if they had not known each other by sight. The combination which I have described, a masterful but considerate president, strong enough and fair enough to invite frank counsel, with a faculty willing to give this counsel in a broad spirit of loyalty, has existed, I believe, not in one institution alone, but in many. With this combination formal checks and balances of authority are needless; without it they are of little avail. It seems to me the "necessary and sufficient" condition of genuine success for a university dealing with educational problems as they exist in this country. In using the term faculty I mean a body which controls the instruction leading to some degree or degrees, and I am not advocating general meetings of all the various faculties which may exist together under the university name. It is unlikely that any president could feel himself equally a master of the situation in all the various faculties, arts, law, medicine, etc., of a modern full-fledged university; but the advantage of having some one active man to preside at all meetings of these faculties, to watch, and report upon, and in a measure control, the relations of the several faculties to each other, seems great. A "chancellor" for show occasions, "to represent the university at public functions" or even "to obtain endowments," would, I think, be ineffective in comparison. As to the selection of professors, I fear that the plan of having all nominations come from departments might result in that condition of academic inbreeding which is noted in some places. At any rate, the faculty selection of professors appears to have had a tendency toward this condition in certain institutions. I am sorry to take issue with you on some of your most important propositions, for I agree with much that you maintain, and especially with your declaration that "security, permanence, honor, the slow growth of traditions, are essential to a true university." The proposition that great salaries are needed to induce able men to enter university positions, or that great salaries would bring into university professorships the best men, on the whole, for these places, I hold to be fallacious. Great salaries are not needed to call great lawyers from the gainful practise of the bar to the security and honor and sense of public service which they find on the bench. Every teacher, every "productive scholar," should feel himself to be a servant of the public, of a public wider, it may be, than any judge can serve. He should bear himself, and be honored, accordingly.

The plan which you outline is an interesting one which I should be glad to see tried as an experiment somewhere where I am not. The gravest danger I see in it is the proposition that professors be nominated by the departments. This would almost inevitably have the tendency to cause the promotion of men already in the departments, rather than the securing of the best man available, if he happened not to be there. The method of nomination by a faculty composed of only the full professors, as is the case in Germany, obviates this difficulty, since the full professors are no longer looking for advancement, and an appointment from outside will not put any one ahead of them as would be the case for all other members of the department. I am not at all sure that even this method of selection by a faculty of full professors is superior to the present methods commonly in vogue. Yale, I believe, has such a system, and I do not see that the appointments there have been unusually strong. The main reason why I feel doubt about your scheme is that the averages of our faculties the country over are still so low intellectually. Mediocrity is the almost unbroken rule. No doubt this will improve in time; it has improved greatly during

the last twenty years. At present, however, I feel that we have a better chance to secure men of intellectual alertness in the president's chair than as a composite photograph of a faculty or department. The catch-words of democracy and autocracy do not appeal to my judgment here. Of course I am with you in desiring to see the universities and colleges of the country so administered that the faculty members shall not feel that they are merely employees of the corporation (trustees), but that they have a large share in deciding policies and in the making of minor appointments. I do not believe it is necessary, to secure this end, to abolish practically as you propose the office of president. I doubt whether during the present generation at least a satisfactory substitute for the president can be devised.

The organization proposed under (1), (2), (3) and (5) depends for its success largely on the possibility of finding a man with the requisite qualifications for president, and securing his election. In throwing the responsibility for this choice directly on the faculty it would have a wholesome effect on this body. But whether any man with no more power given him than you propose for the president could become a leader is doubtful. Certainly Mr. Eliot could not have accomplished what he did for Harvard under this plan. But conditions have changed since then, and more could be done with the plan now. Still, are not our faculties too much bound up in the supposed interests of the undergraduate and with the cruder needs of this immature person, to be willing to take any chances when it is a question of higher scholarship? Are we ripe for this plan? I hope we are; but I do not know. The method of making appointments set forth in (4) is, I believe, a wrong one. At the present time there are not enough first-rate men in mathematics in the whole country to supply even the strongest universities, and I presume the situation is similar in other subjects. It is necessary, then, to discover the man who is scientifically strong early, and moreover it is necessary to want to get the man who is scientifically strong. Now the majority of the men whose vote is necessary for a choice under your plan are not themselves scientifically first-rate men, nor do they know a first-rate man when they see him. They are going in any concrete case to impose conditions, each in itself corresponding to a desirable qualification, but all taken together such that the one (or possibly two) otherwise available first-rate men are ruled out. The result will be the choice of an eminently respectable member of society, who as he grows older will add so much more dead wood to the department and in his turn make the choice of a scientifically strong man difficult or impossible. If really strong appointments are to be made, the choice must rest ultimately with one or two men, as the president and the head of the department; and even two is sometimes too many. There have been cases at Harvard where Mr. Eliot has appointed professors from outside without the advice or consent of the departments, much to the good of the department in question. It is true that when both president and the head of a department are incompetent, good appointments are impossible. But only an act of God can save such a department.

I am inclined to think that the best form of government is beneficent tyranny, but of course such a person as Marcus Aurelius should always be chosen as tyrant. That there are some individuals more intelligent than the average, there can be no doubt. The point is to choose these as our leaders. Personally, the less I have to do with the details of running the university, the happier I am.

I have never reflected on the matter of college administration and my opinion is therefore of no value, and might readily be reversed by study, argument or reflection. I see no reason as yet for believing in your plan. A system like that of Harvard seems to me to work well.

Your plan of a representative rather than a town-meeting faculty seems to me excellent.

The rest of the plan seems to me no better than the one in use here, which has stood the test of use admirably.

I rather believe in finding the right man and then giving him a good deal of power. I confess the practical workings of democratic systems do not inspire me with confidence. In short, I believe in a centralized form of government for universities. This is more a matter of personal feeling than anything I can back with logic. I am quite ready to admit that such a system may not work well in a great many cases, though I think it is satisfactory here at Harvard. If the government of a university is to be of a democratic type then I have very little to criticize in your circular. I don't think a president and a chancellor would work very well. Why not have the trustees elect a president who would be commander-in-chief and then let there be a vice-president chosen by the senate to represent the academic side on the board of trustees? As to units, twenty seems to me too small a number. Why not have two or three faculties of fifty or more each? General discussion is a good thing. But these are minor points.

I can do no better than state my own experience in two universities, viz., Harvard and Toronto. First, I must say that I do not regard the university professor as such, as a progressive entity. He appears to me on the whole to be much less progressive than the average non-academic man. As a consequence of this feature of his psychology, it is often to the advantage of the institution, with which he happens to be connected and certainly to the advantage of his more progressive colleagues, if he has any, that he should feel the spur of presidential displeasure at times. When I was connected with the University of Toronto, there were many things which badly needed setting right, so much so that the university was investigated by three royal commissions within a decade. The remedy which was finally chosen was the appointment of an autocratic president of the American type. So far as I am aware the academic machine has worked very well since this change. At Harvard the forces of conservatism, not to say the *vires inertiæ*, are quite as strong as they are in any other university I have had experience of, and I happen to know that the academic lives of some of the members of the Harvard staff who may possibly be more progressive or energetic than their immediate colleagues, would scarcely be endurable, but for the fear of the omnipotent president. This is true not only of President Eliot's regimé, but also of that of the present incumbent, President Lowell. It appears to me that, on the whole, autocratic powers on the part of a university president are a necessary evil. It does appear, however, that there should be some machinery which, in cases of extreme injustice, might exercise a veto on his acts. I do not think that a president having only a limited tenure would be valuable to the university, nor do I believe that it is very desirable to make his position less dignified than it is at present. A very great desideratum at the present time seems to be a professor's protective association, which among its functions might insure its members against unjust loss of position, and which might also act as the advocate of professorial rights in a general way. University professors at the present time in American universities are too much at the mercy of the administration.

I hardly feel qualified to express an opinion about general university organization that would be worth while. I will outline to you the organization that we have in the Harvard Medical School, because it seems to work satisfactorily under our conditions, and this may be of some help to you. (1) The Medical School has an independent budget made up of the income from funds given definitely to the Medical School, and of fees from students. The Medical School pays its proportionate share of the expenses of the general university, such as the president's salary, etc. (2) The Medical School has its own faculty, which is large, as is the custom with Harvard faculties. This faculty is presided over by the

university president, and bears the same relation to the corporation and to the board of overseers of the university as do other Harvard faculties. (3) All teachers appointed for more than one year are members of the medical faculty. These teachers are appointed by the corporation with the consent of the overseers on the recommendation of a committee composed of all full professors in the Medical School. (4) There is a dean of the faculty of medicine, a dean of the Medical School and a dean of the Dental School. The dean of the faculty of medicine is responsible for the preparation of the general business of the faculty. The dean of the schools is responsible for the individual school, its business and its budget. The deans are appointed by the corporation without vote on the part of the full professors. (5) The various departments in the Medical School are organized into six divisions, each division made up of closely allied subjects. Each division elects a chairman, and each member of the component departments who has been connected with the Medical School for more than one year is entitled to a vote. The six chairmen so elected, with the dean of the school, constitute a faculty council, and the faculty council has supervision of matters concerning the curriculum, the extension of the work of the Medical School, etc. To it are referred recommendations from all the divisions and departments for consideration and report to the faculty. In the same way matters brought up in the faculty touching these points are referred to the faculty council for consideration and report. (6) Assistants and instructors reappointed annually are nominated by the professors in the various departments, and their nomination referred to the division acting as a committee on these nominations. If approved by the division, these nominations are sent to the dean, and by him to the corporation for appointment. (7) There is an administrative board of the school appointed by the corporation, which with the dean act upon matters affecting student discipline, to a certain extent financial matters, that is, discussions of appropriations and awards of scholarships, etc. This seems a rather cumbersome organization, and is probably in part the result of the accretions of time. However, under it pretty nearly every one connected with the Medical School has an opportunity in one place or another to freely express his views on matters concerning the policy of the Medical School, and in some way to record them by vote. At the same time those holding more responsible positions are given an opportunity to have a proportionately larger influence on Medical School matters.

So far as the general outline of your plan is concerned, I should express approval. It may interest you if I tell you something of what we have done here in the Medical School within the last two years as the result of an agitation initiated about seven years ago. Two years ago the present organization was adopted, and it works exceedingly well. The departments of the school—the department means all those which give a separate examination, or which have an assistant or full professor at its head—were organized in divisions of allied subjects. There were six such divisions, lettered A, B, C, D, E and F. Division A includes the departments of anatomy, comparative anatomy and the Warren Museum. Division B includes physiology, comparative physiology, biological chemistry, materia medica and therapeutics. Division C includes pathology, comparative pathology, bacteriology, preventive medicine and hygiene, neuropathology. Division D includes theory and practise, clinical medicine and surgery, psychiatry, pediatrics. Division E includes surgery, orthopedic surgery, obstetrics, gynæcology. Division F, dermatology, syphilis, ophthalmology, otology, laryngology. Each division consists of all members of the constituent departments. Those entitled to a vote in the division are members of the faculty, instructors and assistants who have served three years or more. Each division elects its own chairman and a secretary, and matters of interest to any member of the division are brought up for discussion at meetings held for the purpose. The chairmen are

elected for terms of three years, and are not eligible for immediate reelection. The president of the university, the chairmen of the divisions and the dean of the school make up what is called the faculty council. This council considers all questions arising in regard to courses of study or extension of medical study, the general development of the medical school and the creation of new departments, and reports on the same to the faculty of medicine. Questions on such topics may originate in a division and be brought before the council for consideration, or they may originate in the council; but in such case, no matter directly concerning a division or a department shall be referred to the faculty for action until it has previously been referred to a division for discussion and recommendation to the council. Of course there are other details, but I will not make this letter too long by putting them before you. The general plan has now been working for more than two years, and seems to be meeting with entire approbration. Certainly the results are good in that they have brought together men and interests that before were drifting widely apart. It may interest you to know that this scheme is being discussed with a view to its adoption in at least two large medical schools. The essential point in which it differs from the organization of, say, the Johns Hopkins Medical School, is that it increases the dignity of the professor and does not compel a young man who has secured such rank to remain under the control and tutelage of an older professor or else change his university. The fundamental objection to the Carnegie report on medical education has always seemed to me to be the assumption that the Johns Hopkins organization is the best. In the case of that university it undoubtedly worked well, because they were fortunate in securing strong men in the beginning; but certainly the present indications are that they must either reorganize and give some of their juniors independence or else lose them.

It seems to me that the general plan outlined is excellent in so for as it gives a hand in the control of a university to those who are most intimately interested in its welfare; namely, its alumni, its faculty and the section of the community at large which it serves. I think it is also excellent, in so far as it seeks to increase the dignity and respect in which a university chair should be held by all persons. The weakest part of the scheme, as it seems to me, lies in the direction for securing new professorial appointments. It goes without saying that each department of a university contains among its teachers expert judges of the intellectual standing of men outside the university, prominent in various lines of scholarship and achievement. In so far as the faculty members are judges of the standing of outside men, their judgments are of great value, when the question of appointing a new man to an assistant professorship or a full professorship comes uppermost. On the other hand, I think that a faculty may often err in its judgments as to the type of intellectual work that should be encouraged in a university. I think that in some cases experience has shown that faculties invested with the power of appointing new professors, subject to the approval of trustees, have erred grievously in policy, by appointing men too narrowly along certain intellectual lines. For example, I can readily imagine that at some particular university, some particular subject may be taught by the faculty members in its department, who may be staunch supporters of some particular doctrine or line of work. The men in that department are naturally and properly enthusiastic and earnest in their desire to see their favorite line of intellectual work extended. If they are empowered to appoint new faculty members, they are likely, with the best and worthiest of motives, to appoint new men whose views and work lie parallel to their own. The consequence of continuing such elective policy, might, in the course of years, unbalance a university seriously, developing its activities too extensively in some particular lines, to the neglect of other lines equally important. For the above reasons I consider that while the faculty of a university should have some hand in appoint-

ing new members, the president or some equivalent power should be able to prevent the university becoming too one-sided. It should lie in the hands of the president, or equivalent power, to introduce such new men into the faculty as may permit of the university work expanding harmoniously and uniformly. Of course, the appointing power in the hands of a president tends to give large influence to an individual. To counterbalance that tendency, along the lines of your plan, it seems to me that it should lie out of the power of the president to dismiss faculty members except for flagrant cause. Faculty resignations should only be exacted by faculty action. To sum up, I should like to see your scheme amended by giving appointing power, under certain restrictions, to college presidents, but giving dismissing power exclusively to faculties.

The plan you propose has many advantages. In the case of a department devoted to research it is very important that the officers concerned, who are familiar with the subject, should have almost complete control of the administration, especially as regards the appointment of the staff and the plans of work. It is a misfortune when such a department is controlled by a body of men who have no technical knowledge of the work undertaken, or, by personal inspection, familiarity with the investigations actually in progress. It is particularly unfortunate when such a body is more interested in another department of the university and is likely to take action for the benefit of the latter at the expense of the former. The case is like that of the stockholders of a small railway controlled by a larger railway system. Their interests are likely to be sacrificed for the benefit of some portion of the system in which the directors have greater interests. As regards the details of your plan, I think that you go too far in reducing the powers of the president. Every university should have one man of very high grade who would devote his entire time to the work. He must be a man of affairs and capable of keeping the work of the university before the influential portion of the public. I do not believe in the English system of a non-resident chancellor who is simply a figurehead. If the various departments were represented on the governing board, and had the right of nomination as proposed in your (4), the powers of the president would be sufficiently reduced. With these modifications your plan seems to me a good one.

(1) I do not see why members of the corporation should pay annual dues. It seems to me likely that the revenue would be smaller under this system than under the present one in which many men elected to university offices voluntarily give much time and money to worthy objects which they foster. I also think it advisable to keep in all forms of government some degree of subordination and that the best interests of all the professors of an institution are best guarded by having the allotment of funds in the hands of men who are unhampered by personal interest in obtaining an allotment as must be the case where a professor serves as a member of the corporation or body making allotments. The tendency would, I fear, be to work to the advantage of certain professors and departments and against a fair deal for other professors and departments. (2) I think the election of a president by the faculty might be an improvement on the present system. The matter of the salary of the president should be adjusted to circumstances. It is to be presumed that the president has unusual expenses by reason of his office, which unless allowed for, might result in only wealthy men being able to take the position. It seems to me the president should have powers greater than the professor, but perhaps only those which pertain to the chairman of a meeting acting in accordance with parliamentary rules. I would grant him veto power in regard to financial measures. (3) Agreed to, except that a department or division may be able to conduct its affairs wisely when the number of members is less than the minimum of ten prescribed by the "psychological constant." (4) Agreed to. (5) Agreed to. My chief objection to a change from the present system of placing the

control of measures involving expenditure in the hands of non-faculty members of the university lies in the innate division of professors into two groups, those with dominant administrative powers and secondary intellectual accomplishment in their professed field of work, and those with dominant studious habits and without aggressive worldly mindedness such as characterizes the administrator busy with the affairs of his fellows. In the proposed plan it seems to me that the chances are that certain groups of men would more than now develop onesidedness in the policies of a faculty, and that academic politics would receive an additional impulse. But I may be mistaken in this suspicion. The right of the individual professor to vote for representatives should safeguard him in this matter and on the face of it the plan seems to give fair play.

Naturally I do not wholly agree with the proposed plan. I think it is fair to say, however, that I am wholly in sympathy with the spirit of the plan and should agree that our present autocratic government may profitably be modified in the directions which you mention. I suspect that many modifications of the plan would be suggested in connection with any attempt to put it in operation. As I understand your proposition, the chief problem is one of the rôle of the president, and in this I should heartily agree with you that scholarship and research, at least, are likely to be far safer and much more advantageously promoted under the type of administration which exists in European universities than under our own. A wise autocrat may do much to foster the life of a university, but ideal men for such positions are so rare that it seems little less than absurd for our American institutions to continue their present form of administration. I most heartily approve of division organization. With certain slight modifications we might have at Harvard a very efficient organization of this sort, but of course at present all such division units are subordinate in a great variety of ways to the president. One of the most urgent needs in our institutions, it seems to me, is a good method of choosing professors. This, I think, is wisely provided for in your plan. On the whole, I should favor experiments in the directions which you have indicated and should confidently expect that our university government might be very markedly improved. I feel that we need to take account both of American conditions and of the forms of government which have been thoroughly tested, especially in England and in Germany.

I am in sympathy with much you state in this article and fully in accord with many of your views. The question is complex, especially as between state universities and "private" universities.

I believe it would be impossible to foretell what would be the outcome of such a scheme for university organization as you propose, if applied to our American universities. The present situation needs a remedy and your scheme has so many good points that I would favor a conservative trial of it. I am sure that the last sentence on flexibility and anarchy is what we should all strive for.

I agree with most of your suggestions. In my opinion it is practically impossible for the president of a university intelligently to preside over all the different faculties of the university.

The plan of university control outlined in your enclosure appeals to me as admirable in striving to develop a more equable division of effective powers between faculty and president than obtains in most universities at present.

I am entirely in sympathy with your effort toward the administrative improvement of our universities. Professors ought not to be employees but members of the firm.

I sympathize heartily with the views in regard to university control which you propose, but do not feel competent to discuss the entire subject, especially paragraphs (1) and (2). I may say, however, that I have always felt that a small self-perpetuating corporation,

such as that at Harvard, without age limit for its "fellows," although all members of the university are considered incapacitated at sixty-six or thereabouts, is inherently wrong and altogether autocratic. The corporation should be selected by the alumni, by the general body of instructors, or better perhaps by both, and I doubt much if the appointment should be for life.

I am quite in accord with the scheme proposed and raise a question only concerning one point which is included in (4). While in thorough sympathy with the democratic mode of control, I doubt its efficiency. In such departments as I have been connected with, the lower positions are filled more or less temporarily by men who expect to pass on to other higher positions. They have not the responsibility for the department, as is the case with the professor, and as far as my experience has been, they lack interest in the matter of appointments and policy. Furthermore, they are not acquainted with conditions and men to the extent that the head of the department must be in order to make his department a success. In fact, I believe that the head of the department must be "czar" or "boss," so to speak, and those under him must be responsible to him in order to make such a unit a success. In fact, the executive work of a department in my opinion, must be attended to by its head or a person representing him. On the other hand, I believe that it is important that all matters pertaining to the department should be discussed freely by all concerned, and of course in regard to scientific matters there should be the utmost freedom. We have an organization with the unit similar to that outlined in your plan, and it strikes me that there is apathy and a general lack of interest among the younger men.

I heartily approve the general principles of your plan of university control. A plan which secures a separation of the financial and the educational administration is, in so far, a vast improvement over the prevailing plans which ordinarily assume that one governing body may be expert both in business affairs and in educational matters. I favor, too, the more democratic control secured by your plan. I fear, however, that the corporation provided for in (1) of your plan might easily be too large and too freely constituted to be efficient. I should consider it highly unsafe to let the corporation include any "members of the community" who might be pleased to "ally themselves with it" and "pay annual dues." There should be some fairly rigid qualifications for membership designed to exclude all who are not willing to give much of their time and energy to the upbuilding of the university. I see no important function in the office of a chancellor. Why should not the president best "represent the university in its relations to the community," for the university is essentially an educational institution—not a business institution? The further details of your plan, as set forth in (2)–(5), I favor without important exception. The plan of electing professors seems unnecessarily complicated perhaps. Here at Harvard the small division or department enjoys a high degree of autonomy, especially in matters of educational nature, much as your plan proposes. I trust that your agitation of this matter may serve to direct the evolution of our universities along more desirable lines.

In regard to your interesting scheme for university control, paragraph (1) I agree with (with the possible exception of the "members of the community who ally themselves with it"). Would not the alumni of the established university be enough representation? I also agree with paragraph (2). The office should be yearly, or for not more than two years, regarded as a position of dignity, and the election come from the faculties. He should be paid during this time more than a professor, because his work will be greater, more bothersome; he will have to attend functions and dinners and should be compensated for this, particularly for the dinners. In paragraph (3) the unit of organization should be the different faculties. I am not sure about the representation in this, but I think that the

representatives should be the heads of the various departments, the men who are really responsible for the character of the work in each department. There is a difficulty here with regard to the very large departments, such as history, literature or chemistry in a university. It might be difficult here to single out the one responsible man. The other plan would be by the election of representatives by the departments of the faculties. This would probably be necessary in the philosophical faculty. The maximum of representatives for each faculty should not be more than twenty. In paragraph (4) I agree fully with regard to the election of the dean and the nomination of professors. The board of advisers I also think is an available feature. One of the great difficulties which I see in university management is that of the removal or non-continuance of inefficient men holding minor positions. Of course, such minor positions, including assistant professors, should be for a term of years and at the end of this term the position should be regarded as vacant and be filled by the best man available. It is much easier to say this than to do it. Certainly in our medical schools and in the hospitals, if a man gets into a minor position he is pretty sure to go on to continual advancement irrespective of the character of his work unless this has been very bad indeed. Nominations by a committee will not obviate this trouble because the committee will not seriously consider this.

The American college president is certainly an anomaly in education; and the wonder is that the system involving him works on the whole so well. Certainly university faculties do not seem well qualified to manage universities; and state or national educational boards are to be dreaded—Heaven save us! Does not the existence of the present system show that faculties are unbusinesslike and are willing to have some one manage for them? The present method presents a strong contrast to that of the directors of a mill or manufacturing company—where the matters germane to the industry are discussed by a board of directors with a president who is the executive officer. Imagine the feelings of the directors if the president should go to another body, on which the directors have no representative, and state the opinions of the directors as he understands them, or as he desires them to be understood. This is the condition in most of our universities. The faculties should shape the educational reforms of the universities—in a council consisting of not more than twenty men—heads of great departments. The president should carry the votes of such a council to the business and legal councils of the university to ascertain if there are practical objections to the plans of such an academic council. Why should one man assume to shape the educational future of a university?

It seems to me that the cooperation of all faculty members above and including the rank of instructor, should be desired, but how to get this is not clear to me. If the appreciative sympathy of all the faculty is not had, the control surely will go to the "old guard" and there it will remain, not permitting the careful and at the same time progressive policies essential to the health of the university, as a whole, or it will be taken over by some clique, which would be equally undesirable. Perhaps the end could be best attained by the adoption of a near-republican form of control, by which as much authority as feasible could be delegated, but in which all faculty members including instructors should have the right to vote and should be eligible for service on appropriate committees. The chief executive officer should be elected by this voting body, and for a definite term of years. The professors should also be elected by the same body, but for an indefinite period. I have no comment to offer on your suggestions except the single one, that they appear to me to be sound in every particular and worthy of serious consideration. Such universities as have barely escaped shipwreck through the use of wrong policies in control could well follow the plan laid down by you with great profit.

SCIENTIFIC BOOKS

Vergleichende Anatomie des menschlichen Gebisses und der Zähne der Vertebraten. Von Dr. Paul de Terra. Jena, Fischer. 1911. Pp. v + 451. Mit 200 Textabbildungen.

Thoroughly Germanic is the stamp of this work: in its tireless massing of details, in its bibliography of three thousand titles and no less in its comparative anatomy.

The author, Dr. Paul de Terra, "vorm. Zahnartzt in Zürich," has not been content to regard the human dentition solely as the subject matter of a lucrative profession, but conceives odontology rather as a branch of morphological science. After a section devoted chiefly to the masticatory apparatus of vertebrates and to the development of the mouth cavity and its parts we find an apparently reliable account of the dentition in general, dealing with the macroscopic and microscopic form, the development and calcification of the milk and permanent dentitions, the mechanism of replacement, the reduction and degeneration of teeth, supernumerary teeth, chemical composition of the dental elements and the like.

The author is of the opinion that odontology is still very largely an empirical science with no great number of well-founded doctrines. He says it is difficult, in view of the multitude of controversial matters, to write a consistent text-book of odontology. He has, therefore, striven to state all sides of the controversial questions with great impartiality. This is perhaps the reason why matters relating to evolutionary origins are left in such great uncertainty and why the now well-discredited and thoroughly archaic hypothesis that the molars of mammals arose through the concrescence of single peg-like teeth is treated with so much respect.

The "theory of trituberculy" is very briefly expounded, but without help from Osborn's later researches, especially "The Evolution of the Mammalian Molar Teeth," 8vo, 1908, which the author does not quote even in his bibliography. It is to be hoped that some day writers of text-books on zoology and odontology will become aware that the strong and well-founded part of the theory of trituberculy is *not* the view that the tritubercular molar arose from the triconodont and protodont types through "migration of the cusps"—a view that rests upon the slenderest of analogical evidence.

Another desideratum is the final rejection of one of the early trituberculy diagrams (reproduced on page 62 of the work under consideration) which has unfortunately gained a wide currency in text-books. This diagram, which purports to show the spatial relations of the cusps of the upper and lower molars when in contact, is thoroughly misleading, because no teeth known fit together in the way there represented. In every tritubercular-tuberculosectorial dentition, as well as in derived types, the protocone of each upper molar fits squarely into the talonid and behind the trigonid of the corresponding lower molar; as the hypocone is developed it reaches into the valley of the trigonid of the next following lower molar. Primitive Marsupials, Rodents, Insectivores, Carnivores, Primates, "Ungulates" of all orders, all conform to this rule, which furnishes a complete clue to the spatial relations of all parts of the upper and lower molars when in contact. As the reviewer has elsewhere shown, this fact has an important bearing on the derivation of the tritubercular dentition. The alternating relationship of the parts of the upper and lower molars was probably established very early in the history of the Mammalia and is indeed clearly foreshadowed in some of the extinct mammal-like reptiles of South Africa (*e. g., Diademodon, Sesamodon*).

It is unfortunate that the author with all his diligence should have made so little effective use of contemporary vertebrate paleontology which might have furnished him with a well-organized method of interpreting at least in part his great compilation of undigested facts about the dentition of fishes, amphibians, reptiles, birds and mammals, a subject covering about 200 pages of the present work. If one wishes to know how many teeth

there are in the jaws and of what kind they are, in recent forms and in a good many fossil forms, he will most likely find here a careful statement of the facts, which is after all the professed purpose of the book. Certain it is, however, that such odontographical information is merely the beginning and not the end of odontology, conceived as a division of comparative anatomy.

WILLIAM K. GREGORY

Modern Industrial Chemistry. From the German of H. BLÜCHER. Translation by J. P. MILLINGTON, M.A. (Cantab.), B.Sc. (Wales), formerly Scholar of Christ's College, Cambridge. The Gresham Publishing Co., 34 and 35 Southampton St., Strand, London. 1911.

According to the publisher's note, this volume is put forward as a standard work, now for the first time issued in an English translation, designed to cover the whole range of subjects with which the chemist and manufacturer are usually concerned. It is not intended as a text-book, but to occupy a position between the text-book and the lexicon. It is arranged in strictly alphabetical order and should therefore be regarded as a dictionary of chemistry.

It is conveniently issued in a single volume of 780 pages. With the exception of the convenience of having a compendium of this sort issued in a single volume, it is difficult to see in what respect this work presents any advantages over the standard dictionaries of chemistry such as those of Thorpe and Watts. It certainly can not be called up-to-date. Many of the leading industrial processes and products are not well handled, especially from the standpoint of American industry. The treatment of the chapter on industrial alcohol, for instance, is not in accordance with the best modern information, and the same may be said of the article on sugar manufacture. Under the descriptions of asphalts, petroleums, tars, etc., many of the statements seem arbitrary and misleading from the standpoint of American technology. The translator has evidently found considerable difficulty in finding synonyms for German technical names and phrases. The properties of both asphalts and tars, as related to their residual products, now so much used for paving purposes, are inadequately treated, and unimportant patented preparations seem to be given too much prominence. Water gas tars, for which considerable uses have been found, are not mentioned in the volume.

Under pigments and oils, we find a very fair but brief description of the various dry colors, mineral and artificial, as well as pigments used in the manufacture of paints. The treatment of the manufacture of white lead is, however, very old, and does not include any mention of the new processes now in use both in America and abroad, such, for instance, as the Rowley or the Picher processes. All of the more common oils and thinners for paints are briefly described, and considerable matter concerning the manufacture of varnishes is included. The newer paint oils which have come into prominence of late years are not mentioned.

Metallurgical processes are described only briefly, and for the most part the descriptions do not adhere to the usual or best practise common in American metallurgy.

Perhaps the most useful feature in the volume is comprised in the digest of foreign and local patents, which touch upon a number of the principal subjects cited and which afford considerable data for reference purposes. The book is well printed and presents an attractive appearance. It will undoubtedly be a valuable addition to a reference library for the chemist or manufacturer, but should not be accepted as authoritative or up-to-date in all the numerous subjects which are covered.

ALLERTON S. CUSHMAN

SCIENTIFIC JOURNALS AND ARTICLES

THE April number (volume 13, number 2) of the *Transactions of the American Mathematical Society* contains the following papers:

G. A. Bliss: "A generalization of Weierstrass's preparation theorem for a power series in several variables."

W. D. MacMillan: "An existence theorem for periodic solutions."

W. F. Osgood: "A condition that a function in a projective space be rational."

J. C. Fields: "A method of proving certain theorems relating to rational functions which are adjoint to an algebraic equation for a given value of the independent variable."

M. B. White: "The dependence of focal points upon curvature for problems of the calculus of variations in space."

J. E. Hodgson: "Orthocentric properties of the plane directed n-line."

S. E. Urner: "Certain singularities of point transformations in space of three dimensions."

J. R. Conner: "Multiple correspondences determined by the rational plane quintic curve."

The March number (volume 18, number 6) of the *Bulletin of the American Mathematical Society* contains: Report of the winter meeting of the Chicago Section, by H. E. Slaught; "An identical transformation of the elliptic element in the Weierstrass form," by F. H. Safford; "Surfaces in hyperspace which have a tangent line with three-point contact passing through each point," by C. L. E. Moore; "Note on mixed linear integral equations," by W. A. Hurwitz; "Note on the graphical solutions of the fundamental equations in the short methods of determining orbits," by A. O. Leuschner and B. A. Bernstein; "On a functional equation," by A. R. Schweitzer; "Shop mathematics," by C. F. Warner with rejoinder by C. N. Haskins; "Shorter Notices": Dumont's Arithmétique générale, by N. J. Lennes; Schur's Grundlagen der Geometrie, by F. W. Owens; Appell and Dautheville's Introduction à l'Etude de la Physique et de la Mécanique appliquée, by J. B. Shaw; Crelier's Systèmes cinématiques, by Arnold Emch; "Notes"; "New Publications."

The April number of the *Bulletin* contains: Report of the February meeting of the society, by F. N. Cole; "On the foundations of the theory of linear integral equations," by E. H. Moore; "Shorter Notices": Young's Fundamental Concepts of Algebra and Geometry, by E. B. Lytle; Friedel's Leçons de Cristallographie, by J. B. Shaw; Andoyer's Nouvelles Tables trigonométriques fondamentales, by E. W. Brown; Annuaire du Bureau des Longitudes pour l'An 1912, by E. W. Brown; "Notes"; "New Publications."

SPECIAL ARTICLES

TERTIARY DEPOSITS OF EASTERN MEXICO

Our investigations during the past year on the eastern coast of Mexico have brought out very important facts in connection with the historical geology of the Gulf Coast.

As stated in this journal a year ago,[1] deposits which are lithologically and faunally the same as those referred to the Eocene in the Texas Coastal Plain were traced southward through northeastern Mexico to the Conchos or Presas river. Fossils characteristic of substages of the Texas Claiborne were found on this river, and beyond it the sediments were traced southward to a point a few miles north of Abasola, where they passed from sight beneath the overlap of the San Fernando Oligocene. The materials of the Eocene throughout this region are clays and sands in all respects similar to those of the Texas area and the fossils are species practically identical with those of that region.

The materials of the Oligocene are yellow clays and sands with thin beds of impure limestone, carrying an abundant fauna. These beds are not represented at all in the Texas area between the Brazos and Rio Grande. If they were ever present they have been eroded or concealed by the overlap of later beds.

From the point north of Abasola, where the San Fernando is found resting upon the Papagallos shales of the Cretaceous, this contact continues southward along the eastern border of the valley of the Soto la Marina river to the town of the same name; then it parallels the eastern flank of the Tamaulipas range, drawing gradually nearer the Gulf shore until, in the vicinity of Tordo bay, the Cretaceous is found within 8 miles of the coast.

[1] Science, Vol. XXXIII., No. 841, pp. 232–234.

No deposits in any way similar to those of the Eocene of this northeastern region have so far been observed south of Abasola, which is 120 miles north of Tampico. The last characteristic Gulf Coast Eocene fossils were found on the Presas river 160 miles north of Tampico.

In the region to the south and west of Tampico an entirely different condition exists. The Papagallos shale continues along the western border of the lowland and also occurs as inliers in the later formations. It is a compact blue shale, more or less calcareous, and up to the present we have found no fossils in it.

It is succeeded by a shale so similar in color and general structure as to make a separation extremely difficult, unless one is fortunate enough to find the fossils which occur here and there in it. One such locality is that on the Buenavista River near Alazán, some 25 miles northwest of Tuxpam and 75 miles south of Tampico. A collection of fossils made at this point by Professor Cummins shows a fauna consisting principally of small gasteropods with a few bivalves, many of which are very similar to, and some identical with, those of the Tejon beds of the Pacific coast. More detailed examinations will doubtless result in recognizing these beds at many other localities, since they unquestionably underlie a large area. They may even extend northward through the valley in which the Tampico and Monterey railroad runs, since we found similar fossils in a well at Topila at a depth of 1,810 feet. From this locality we have the following forms as determined by Mr. G. C. Gester:

1. *Dentalium stramineum* Gabb.
2. *Surcula monolifera.*
3. *Turris* n. sp. (near but not *Claytonensis*).
4. *Olivella near-mathewsonii.*
5. *Corbula* (species not determined but identical with a specimen from Marysville Buttes Tejon).
6. *Tritonium* (*Murex*) n. sp. (identical with material from Marysville Buttes Tejon).
7. *Conus remondii.*
8. *Neverita secta* or *Lunatia hornii* (Gabb).
9. *Neverita secta* var.
10. *Tritonium* sp. (identical with specimen from Marysville Buttes).
11. *Turris* n. sp.
12. *Turritella.*
13. *Cerithium.*
14. *Eulima?*
15. *Acteon?*

Out of the fifteen species here enumerated, five are identical with Tejon species and six others are very closely related to them.

Not only are the fossils of this area of Pacific coast types but the sediments are similar to those of that area and entirely different from those of the Texas region.

These Alazan shales are overlain directly by the yellow clays of the San Fernando, which are well exposed both west of the Buenavista River near Alazan and eastward between Solis and Meson. Large quantities of fossils are found, including *Orbitoides papyrycæa,* echinoderms, pectens and many species of this as yet unstudied fauna. These yellow clays and sands are the surface material over a large portion of the coast country between Tuxpam and Tampico and its fossils were found at a number of places in this area. It is succeeded by beds of similar composition but later age, which are found only in a narrow belt along the coast itself.

It appears that from the beginning of the Oligocene to the Pliocene there was comparatively little change in the character of the sediments, yellow clays and sands making up the bulk of the deposits. The difference of age is, however, marked by change in faunas and the San Fernando is succeeded by the Tuxpam Miocene, which we found near La Loma.

The time equivalency of the Tejon and Claiborne being probable, we find here apparently contemporaneous deposition of the Atlantic and Pacific types of middle Eocene along what is now the same Gulf coast within a comparatively short distance of each other. While we have not yet had time to study the Tamaulipas range with this idea in view, it appears probable that it may represent a part

of the old barrier between the two basins in which this deposition was carried on.

E. T. Dumble

SOCIETIES AND ACADEMIES

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

The 461st regular and 33d annual meeting of the society was held on April 30, at 8 P.M., in the new National Museum, with the president, Mr. F. W. Hodge, in the chair. The following officers were elected:

President—Mr. G. R. Stetson.

Vice-president—Mr. Francis LaFlesche.

Secretary—Mr. William H. Babcock.

Treasurer—Mr. J. N. B. Hewitt.

Additional Members of the Board of Managers—Messrs. G. C. Maynard, Felix Neumann, E. T. Williams, Drs. E. L. Morgan and John R. Swanton.

The following amendments to the by-laws were adopted:

Art. I., Sec. 1, to read: "... Its members shall be classed as Active, Life, Associate, Corresponding and Honorary."

Art. I., Sec. 2, for the words "This sum ... January" the following to be substituted: "Members elected at any time during the first half of the calendar year shall pay the full amount of their annual dues; those elected during the last half of the year shall pay one half the regular annual dues."

Art. I., Sec. 3, to read: "Associate Members are those who, after having been elected, shall have paid the annual fee. The annual dues for Associate Members shall be Two ($2.00) Dollars for each calendar year, payable in January. This sum entitles them to all rights and privileges of the Society with the exception of the *American Anthropologist.*"

Old sections, 3, 4, 5, 6, 7, to read 4, 5, 6, 7, 8.

Art. I., Sec. 5 (formerly Sec. 4), "Proceedings" to be substituted for "Transactions"; "or associate" to be inserted after "active"; "those classes" to be substituted for "that class."

Art. I., Sec. 6 (formerly Sec. 5), for "Transactions," read "Proceedings."

Art. II., Sec. 4, for "quarterly" read "annual"; for "transactions" read "proceedings."

Art. III., Sec. 1, for "alternate Tuesdays" read "third Tuesdays of each month."

Art. III., Sec. 3, after the words "Board of Managers" insert "the President."

Art. III., Sec. 4, insert after "President," "or at the recommendations of three members of the Board."

Art. VI., Sec. 1, to read: "These by-laws may be amended by a three-fourths vote of the Active, Associate and Life Members present at any officially appointed meeting of the Society, provided notice of the proposed amendment shall have been given, in writing, at a meeting held not less than sixty days previously."

Truman Michelson,
Retiring Secretary

THE PHILOSOPHICAL SOCIETY OF THE UNIVERSITY OF VIRGINIA

At the regular monthly meeting of the Scientific Section of the Philosophical Society, held on April 15, 1912, Professor W. H. Echols presented a paper "On the Flow of Water in Artificial Channels, Clean Pipes." The paper may be summarized briefly as follows:

The paper continued the investigations presented two years previous, by proceeding to another degree of precision with wider range of application. The result gives for Chezy's coefficient of resistance m in the expression for loss of head in clean pipes

$$h = m \frac{L}{r} \frac{V^2}{2g},$$

the value

$$m = \frac{.0094 + \frac{.00003}{Vr}}{1 + \frac{.07\,V}{1 + \left(.015 + \frac{.002}{r}\right) V}} + \frac{.6r}{r + .1}$$

r being the mean hydraulic radius and V the velocity expressed in feet and seconds. This value of m applies to the whole class of clean pipes of easy curvature, of glass, brass, tin, lead, zinc, cast and wrought iron coated, riveted iron coated with asphalt. For straight new asphalt coated cast-iron pipes the velocities from the formula should be increased five per cent. and for wooden stave pipes ten per cent. Four hundred experiments were tabulated in the paper with diameters from one tenth of an inch to eight feet and velocities ranging from two tenths to fifty feet. Three graphical plates accompanied the paper drawn to large scale, giving corresponding values of the coefficients m and c and the relations of V, r and s the hydraulic slope. The paper will be published in the *Transactions* of the society, Bulletin No. 10, Scientific Series.

R. M. Bird,
Secretary